

# SMEX02-SMEX03-SMEX04

## SOIL MOISTURE EXPERIMENTS AND AMSR-E VALIDATION

T. J. Jackson  
USDA ARS  
October 21, 2003

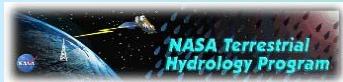
# **SMEX02-SMEX03-SMEX04**

- Objectives
- Experiment Design
- Sites
- SMEX03 Report
- SMEX03 Brazil Update
- SMEX04 Plan
- DAAC

# **SMEX Science Objectives**

- **Validation** of Aqua AMSR-E soil moisture products for a range of land cover types
- Development and verification of soil moisture retrieval **algorithms** for a range of biomass levels for current (C Band) and future (L Band) passive microwave missions and **Envisat ASAR**
- Soil moisture sampling-scaling, **calibration** and method
- Demonstration of new soil moisture retrieval concepts and **technologies** (GPS, 2DSTAR)
- Robust data sets for follow-on **modeling** including **land atmosphere interactions**

# Soil Moisture Experiments (SMEX)



- Science



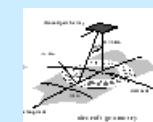
- Water Cycle



- Algorithms



- Validation



- Technology

- Satellite Instruments

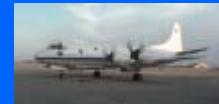


- AMSR-E
- AMSR
- SSM/I
- TMI
- Envisat, ERS-2, Quikscat
- Coriolis
- MODIS, ASTER
- TM
- GOES, AVHRR



- Aircraft Instruments

- PSR
- ESTAR/2DSTAR
- GPS
- AIRSAR



- Sites

- Iowa
- Oklahoma
- Georgia
- Alabama
- Brazil
- Arizona
- Mexico

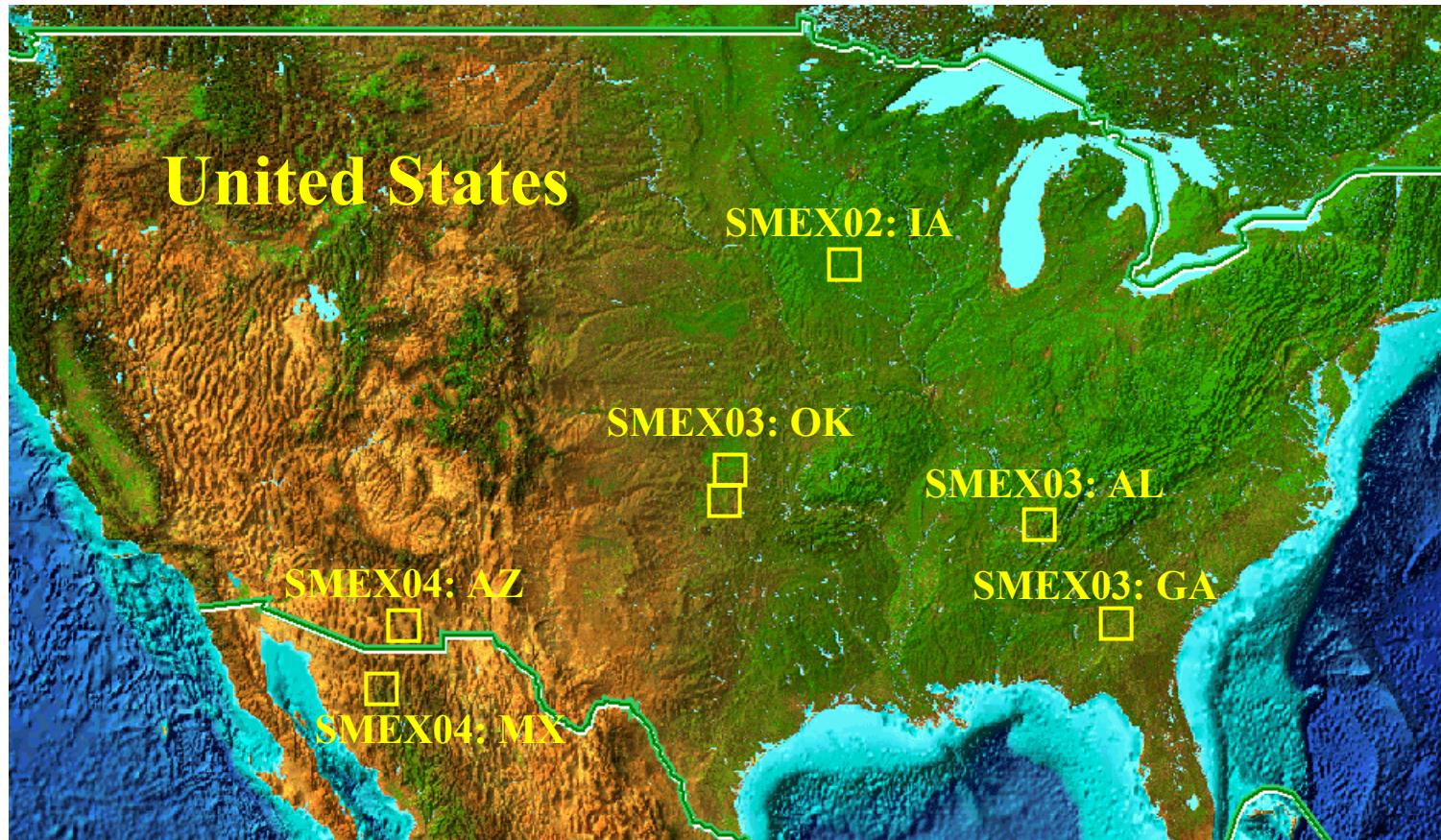


- Ground Investigations

- Soil moisture
- Soil temperature
- Surface flux
- Vegetation
- Surface roughness
- Ground based radiometry
- Insitu calibration
- Insitu scaling



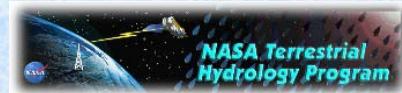
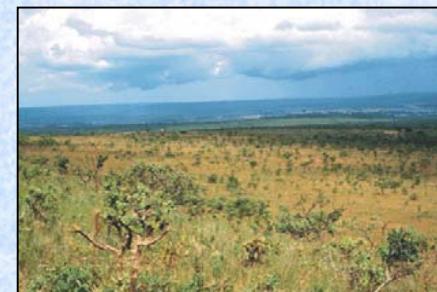
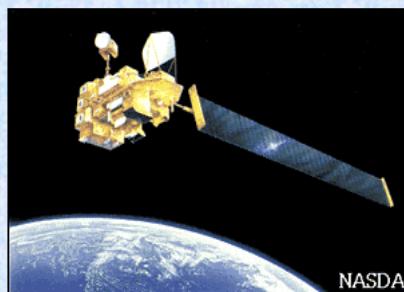
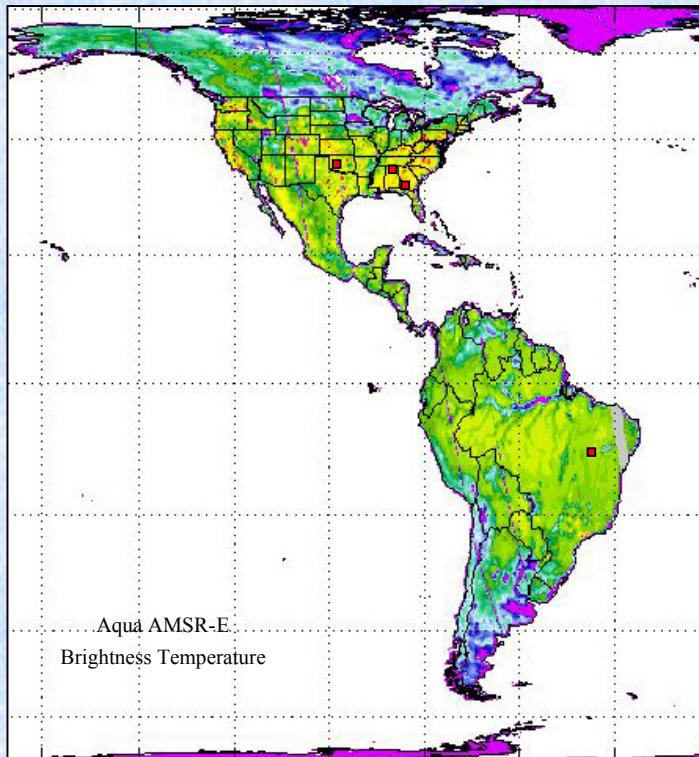
# SMEX: A Series of Intensive Field Campaigns Incorporating Diverse Land Covers and Climates



# SMEX: A Series of Intensive Field Campaigns Incorporating Diverse Land Covers and Climates



# Soil Moisture Experiments 2003



## SMEX03



# SMEX03 Data Acquisitions June-July 2003

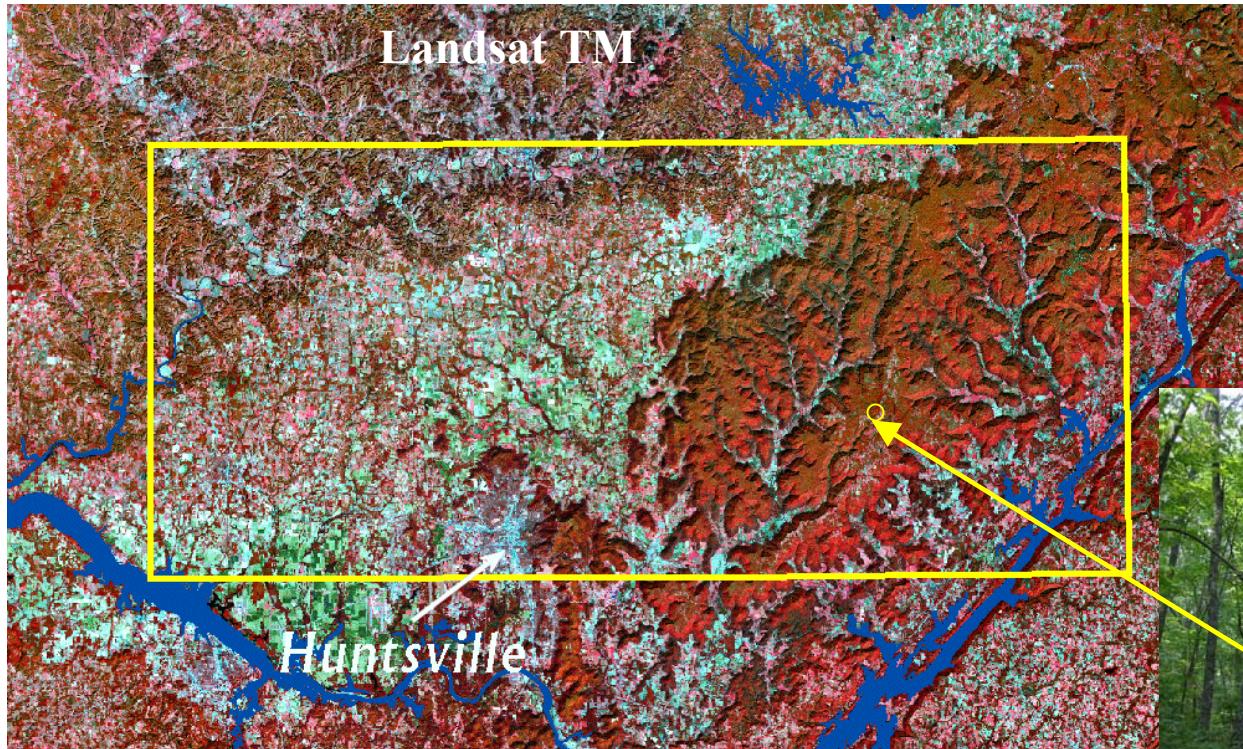
| 22     | 23       | 24     | 25     | 26     | 27       | 28          |
|--------|----------|--------|--------|--------|----------|-------------|
|        |          |        | AL, GA |        | AL       |             |
|        | AQ AD CO |        | AQ     | AQ AD  |          | AQ AD CO    |
| 29     | 30       | 1      | 2      | 3      | 4        | 5           |
| AL, GA | AL, GA   |        | GA, OS | OS, ON |          | OS, ON      |
| AD     | AQ       |        | AQ CO  | AQ CO  | AD CO    | AQ AD CO    |
| 6      | 7        | 8      | 9      | 10     | 11       | 12          |
|        | OS, ON   |        |        | OS, ON | ON       | OS, ON      |
|        | CO       |        | AQ AD  | AD     | AQ CO    | CO AQ AD CO |
| 13     | 14       | 15     | 16     | 17     | 18       | 19          |
| OS, ON | OS, ON   | OS, ON |        | OS, ON |          |             |
| AD     |          |        | AQ     | AD CO  | AQ AD CO | AD          |

Date

P3 Coverage (AL=Alabama, GA=Georgia, OS=Oklahoma South, ON=Oklahoma North  
 Satellite Coverage (AQ=Aqua, AD=ADEOS-II, CO=Coriolis)

# NASA P-3B SMEX03 Alabama



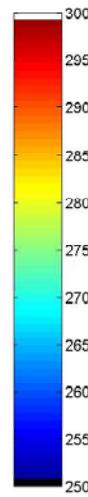
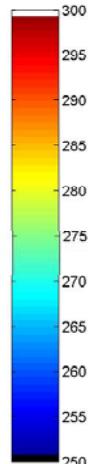
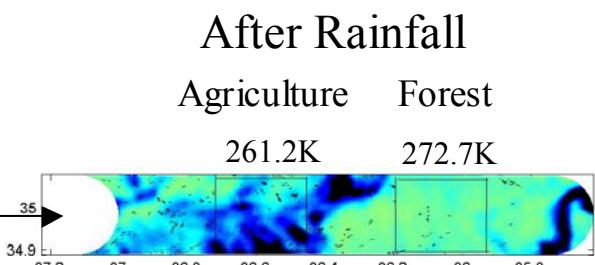
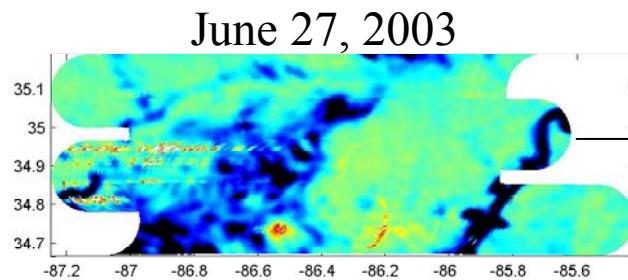
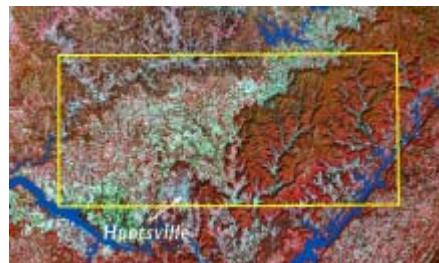
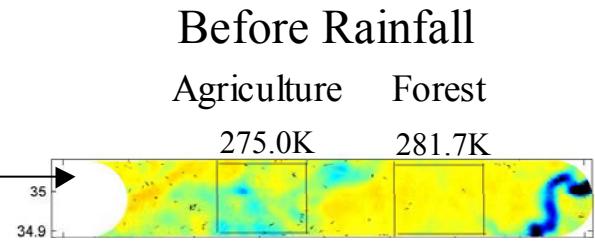
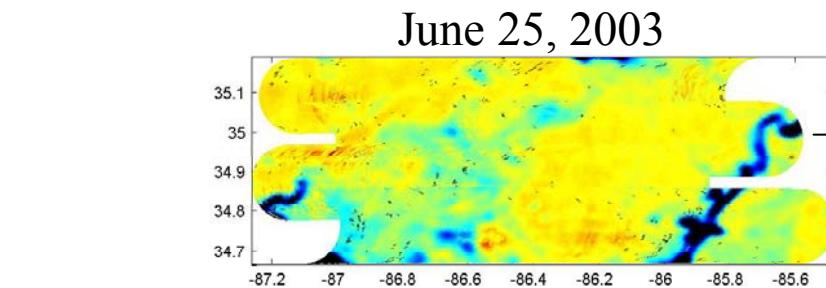


**Forest Vegetation  
Water Content Estimates  
From MODIS  
Leaf  $\sim 1.6 \text{ kg/m}^2$   
Total  $\sim 18.0 \text{ kg/m}^2$**



HYTOP SCAN SITE

# SMEX03 Alabama PSR 7.32 GHz H Channel Brightness Temperature



# SMEX03 Georgia

## Site Condition Examples



Pine Forest



Peanuts



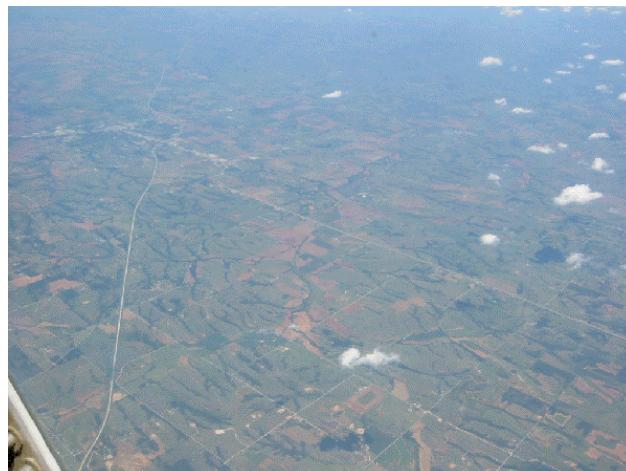
Cotton

# SMEX03 Oklahoma

## Site Condition Examples



Bare Soil (Winter Wheat)



Rangeland

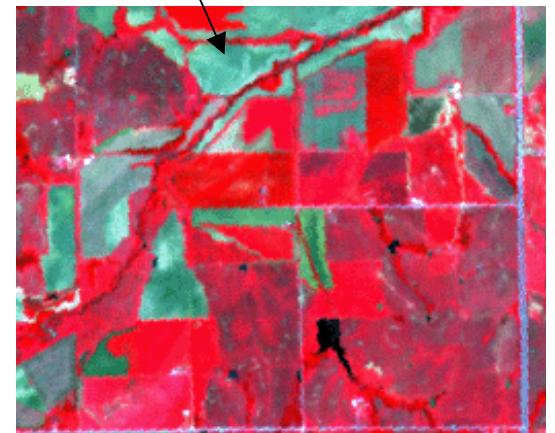
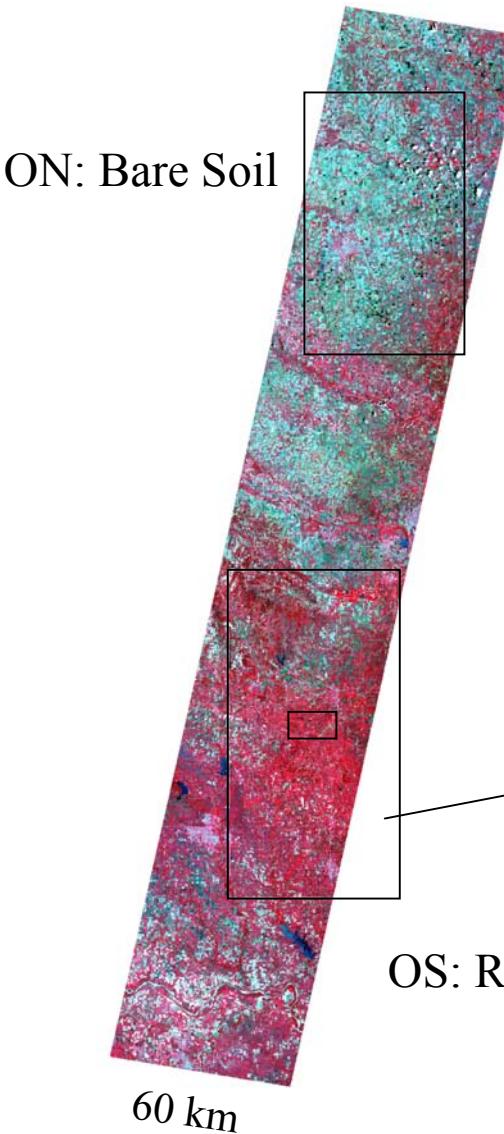


# Terra ASTER

## July 2, 2003 False Color Composite

### SMEX03 Oklahoma Sites

#### (OS, ON and LW)



ASTER data were also acquired on  
July 18, 2003

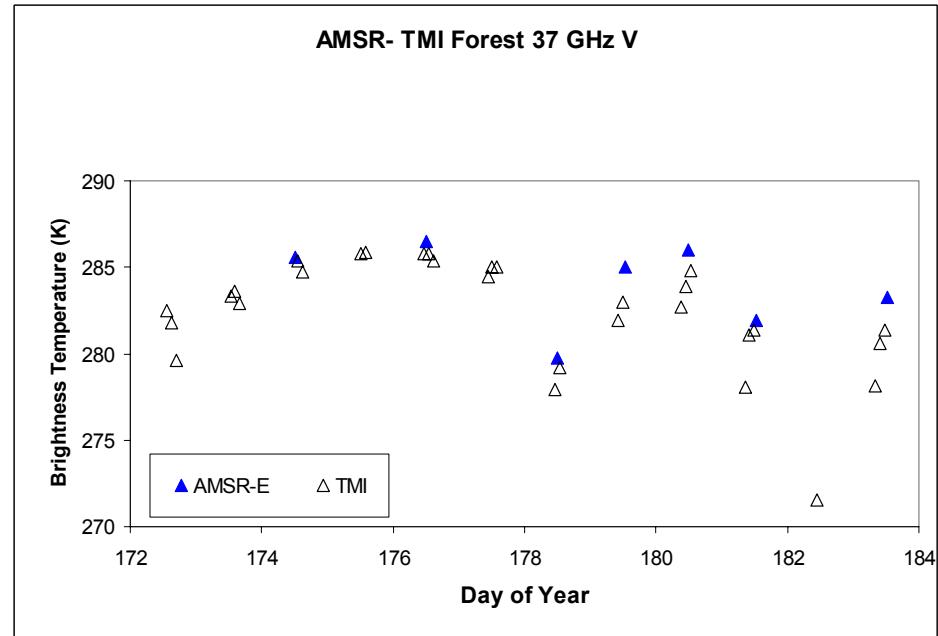
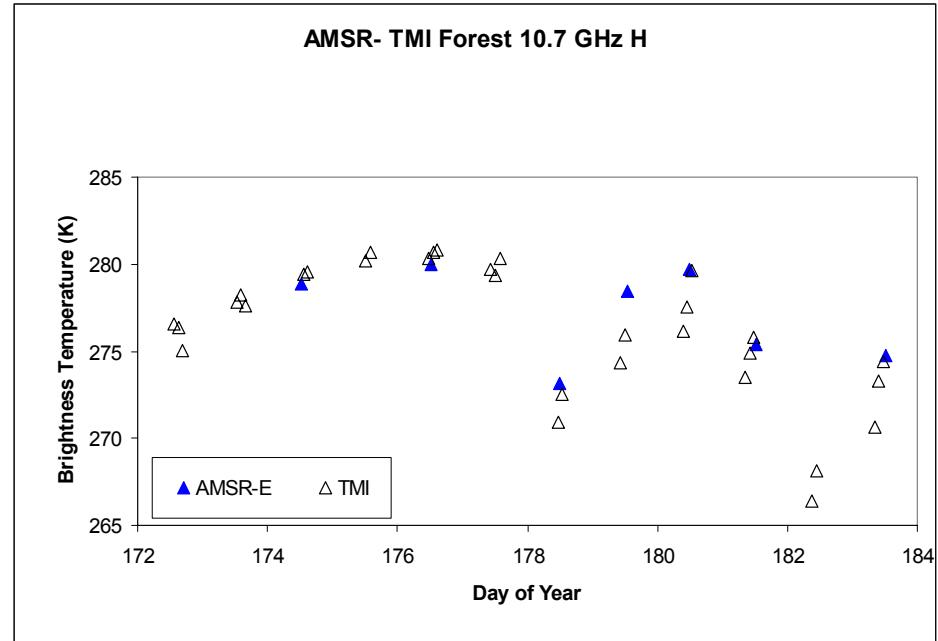
# **SMEX03 Brightness Temperature Validation**

- Preliminary for Alabama area (AL) separated into two parts (Forest and Agriculture)- Ascending data
- AMSR-E vs. TMI
  - TMI coverage time varies
  - Examples-10 GHz H and 37 GHz V Forest
- AMSR-E vs. PSR
  - Minor variations in overpass times
  - X band channels of both AMSR-E and PSR match for both Forest and Agriculture
  - C band channels match for Forest but show large differences for Agriculture: **AMSR-E RFI**

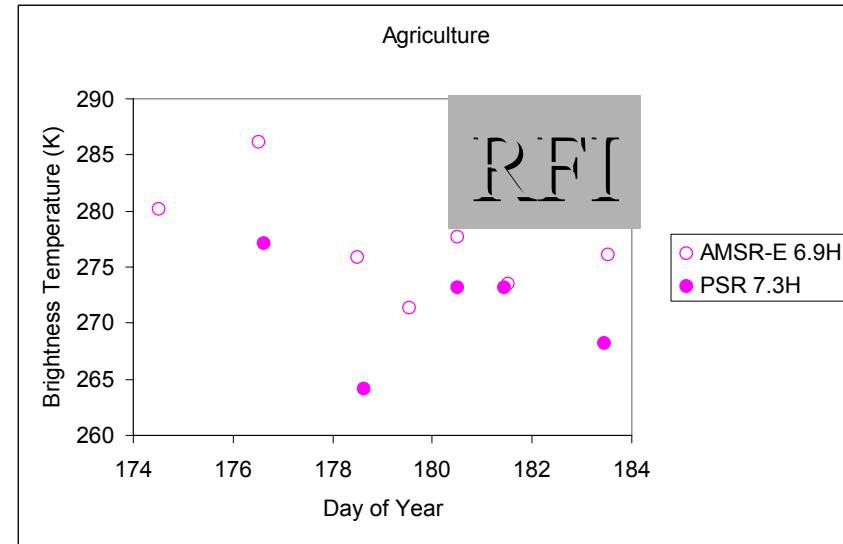
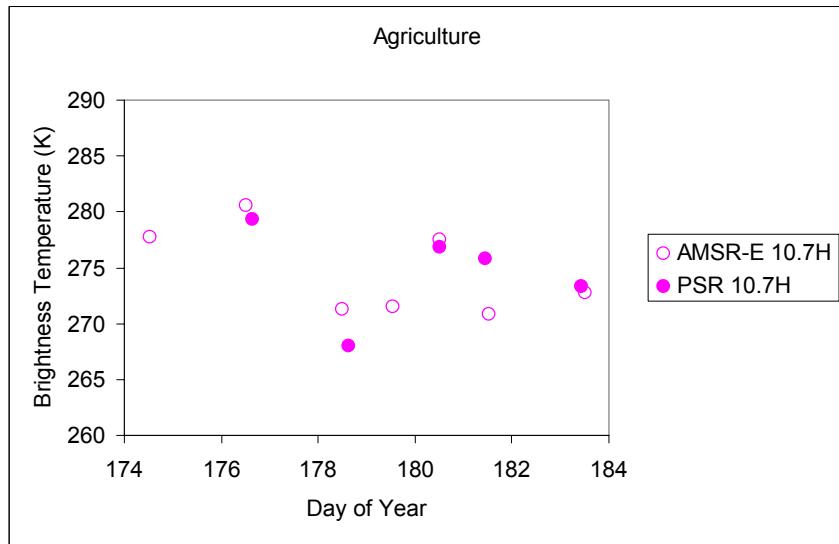
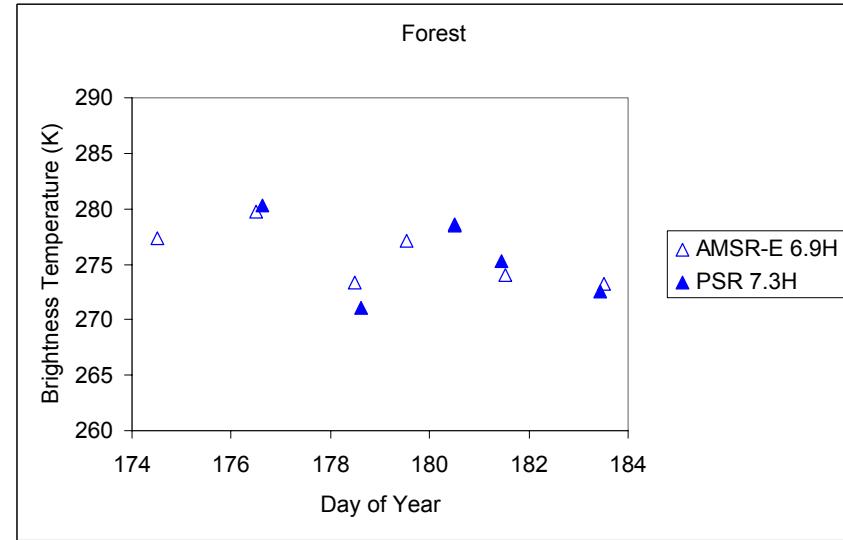
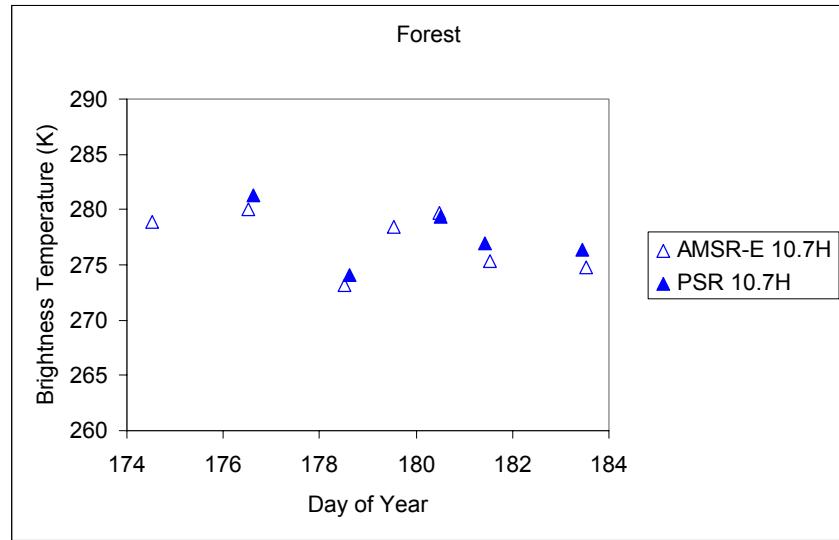
# SMEX03 AL

## AMSR-E and TMI Brightness Temperature Comparisons

TMI overpass time varies day to day and there are multiple passes



# SMEX03 AL: AMSR-E vs. PSR



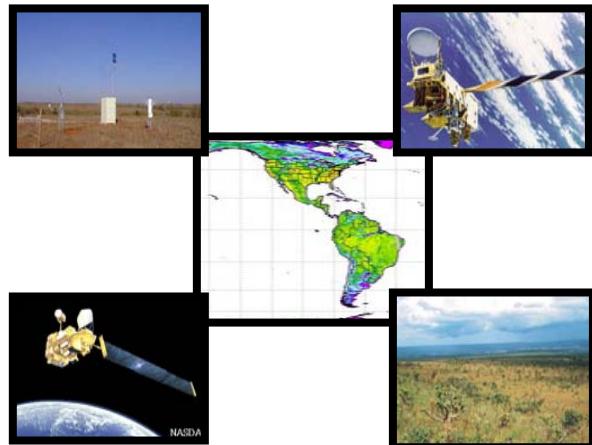
# SMEX03

## Brazil

### December 2003

# SMEX03

## Experimento de Umidade de Solo de 2003



Investigação conjunta entre  
Embrapa, NASA e USDA para  
compreender as interações entre  
umidade de solo, tempo e clima



A Embrapa, a NASA e o USDA/ARS estão desenvolvendo estudos para compreender melhor a interação entre a superfície da Terra e a atmosfera. Esses estudos fornecerão importantes subsídios para a previsão de clima e tempo.

No segundo semestre de 2003, experimentos de umidade de solo serão conduzidos no Brasil e nos Estados Unidos com o objetivo de entender a influência da umidade de solo e das culturas nas interações entre superfície da Terra e atmosfera (SMEX03).

Este é um projeto multidisciplinar de grande escala que envolve a participação de aproximadamente 100 cientistas e estudantes. As atividades no Brasil ocorrerão no início de dezembro de 2003, num período de duas semanas.

Uma aeronave da NASA transportará instrumentos existentes nos atuais e nos futuros satélites e coletará dados em diferentes altitudes e com alta resolução espacial.

Amostras de campo de umidade de solo e de vegetação serão obtidas concomitantemente com o sobrevôo da aeronave. A área de estudo corresponde à região próxima à sede do município de Barreiras, Bahia.

Essas medidas de campo e de aeronave serão utilizadas para validar os dados do novo satélite da NASA denominado de Aqua, o qual foi construído para compreender o ciclo da água na Terra.

Maiores informações podem ser obtidas no website [hydrolab.arsusda.gov/SMEX03/](http://hydrolab.arsusda.gov/SMEX03/) ou através do

Edson E. Sano (Embrapa Cerrados)  
BR-020 km 18 Cx. Postal 08.223  
73.301-970 Planaltina, DF Tel: (61)388-9904  
[sano@cpac.embrapa.br](mailto:sano@cpac.embrapa.br)

# The Brazilian Cerrado



**Total Area: 208 million ha**

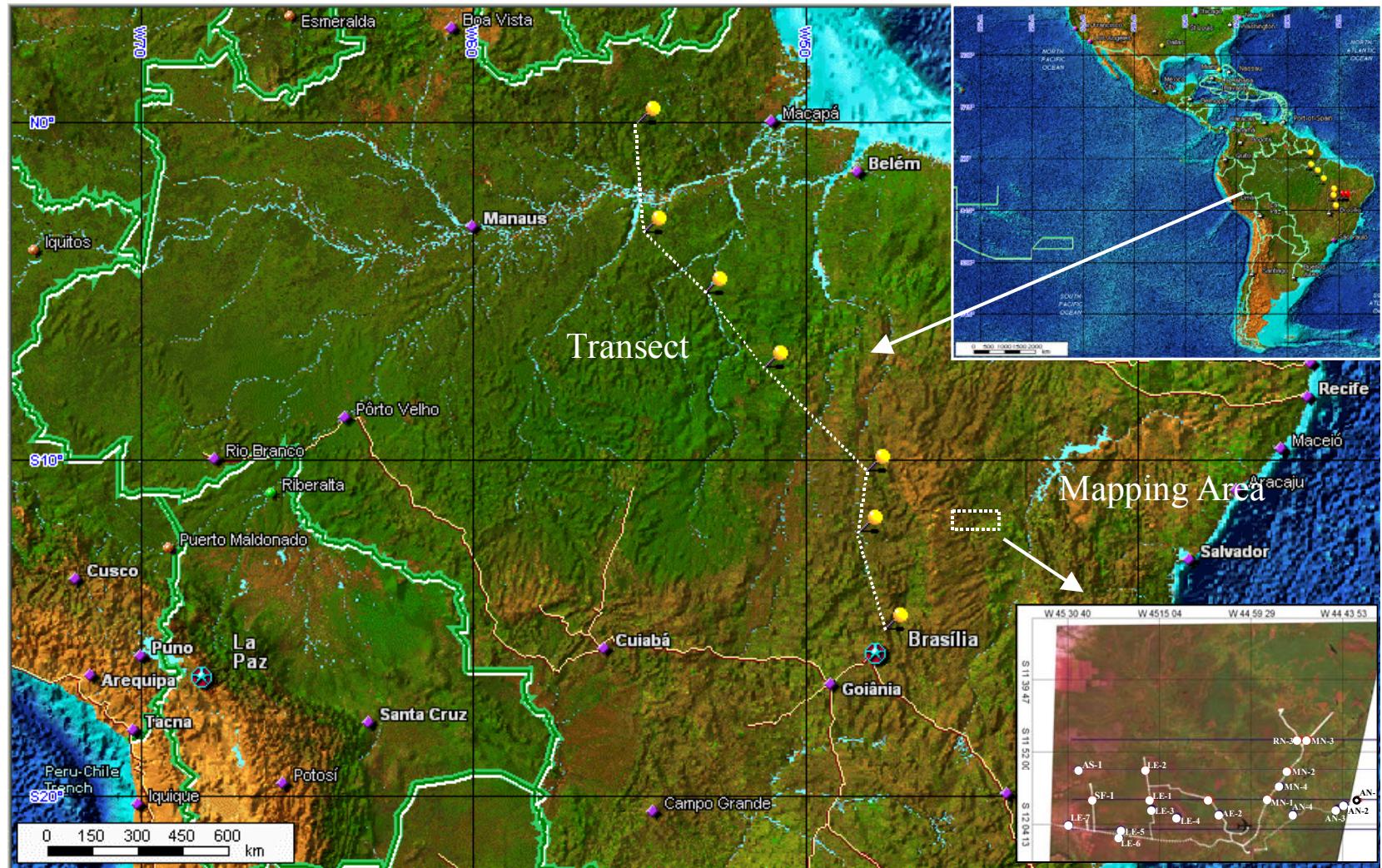
**Cultivated Pastures: 49 million ha**

**Native Pastures: 28 million ha**

**Crops (grains): 10 million ha**



# SMEX03 Brazil Transect Flightline



# SMEX03 Brazil Schedule Information

|   |        |  |    |    |    |    |
|---|--------|--|----|----|----|----|
| <b>30</b><br>P-3B<br>Arrival in<br>Brasilia | 1 Dec. | 2  | 3  | 4  | 5  | 6  |
| 7   | 8      | 9<br>P-3B<br>Departure<br>from<br>Brasilia | 10 | 11 | 12 | 13 |

|                                    |                  |  |                         |                        |                |  |
|------------------------------------|------------------|--|-------------------------|------------------------|----------------|--|
| <b>30</b><br>Satellite<br>Coverage | 1<br>Aqua        | 2<br><b>Aqua</b><br>ADEOS-II<br>Coriolis | 3                       | 4<br><b>Aqua</b>       | 5              | 6<br><b>Aqua</b><br>ADEOS-II<br>Coriolis |
| 7<br>Coriolis<br>Envisat           | 8<br><b>Aqua</b> | 9<br><b>*Aqua</b><br>Transect            | 10<br>ADEOS-II<br>ASTER | 11<br>Aqua<br>Coriolis | 12<br>Coriolis | 13<br>Aqua                               |

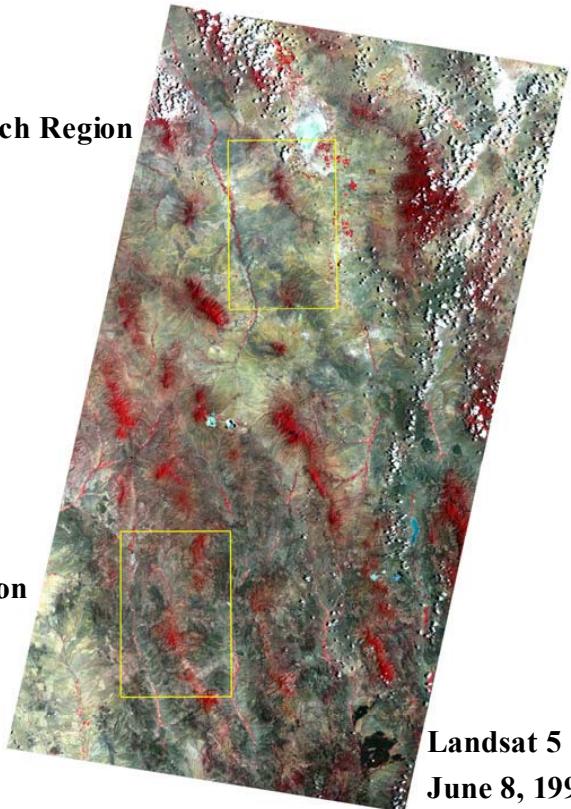


# **SMEX04: Soil Moisture Remote Sensing Field Experiment in the Context of the North American Monsoon Experiment (NAME)**



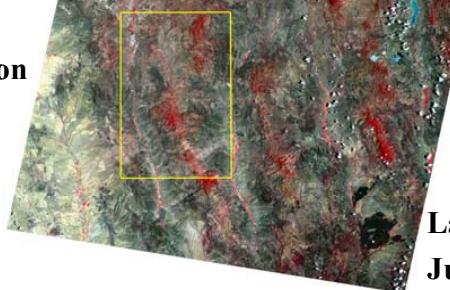
## Arizona

### Walnut Gulch Region



## Mexico

### Sonora Region



In much of the interior of the North American continent, summer precipitation is a dominant feature of the annual cycle. Surface boundary conditions play an important role in initiation and maintenance of the North American Monsoon System (NAMS), which controls summer precipitation over much of this region.

Understanding these processes is a focus for the North American Monsoon Experiment (NAME) <http://www.cpc.ncep.noaa.gov/products/precip/monsoon/>. A working hypothesis of NAME is that among the land surface antecedent boundary conditions that control the onset and intensity of the NAMS is soil moisture. The influence of the land surface is relayed through surface evaporation and associated surface cooling (dependent on soil moisture), terrain, and vegetation cover. Soil moisture and, in particular, surface wetness, can change dramatically after heavy rain events. Increased soil moisture after precipitation promotes evapotranspiration between storm events. This may contribute to enhanced convection and further precipitation.

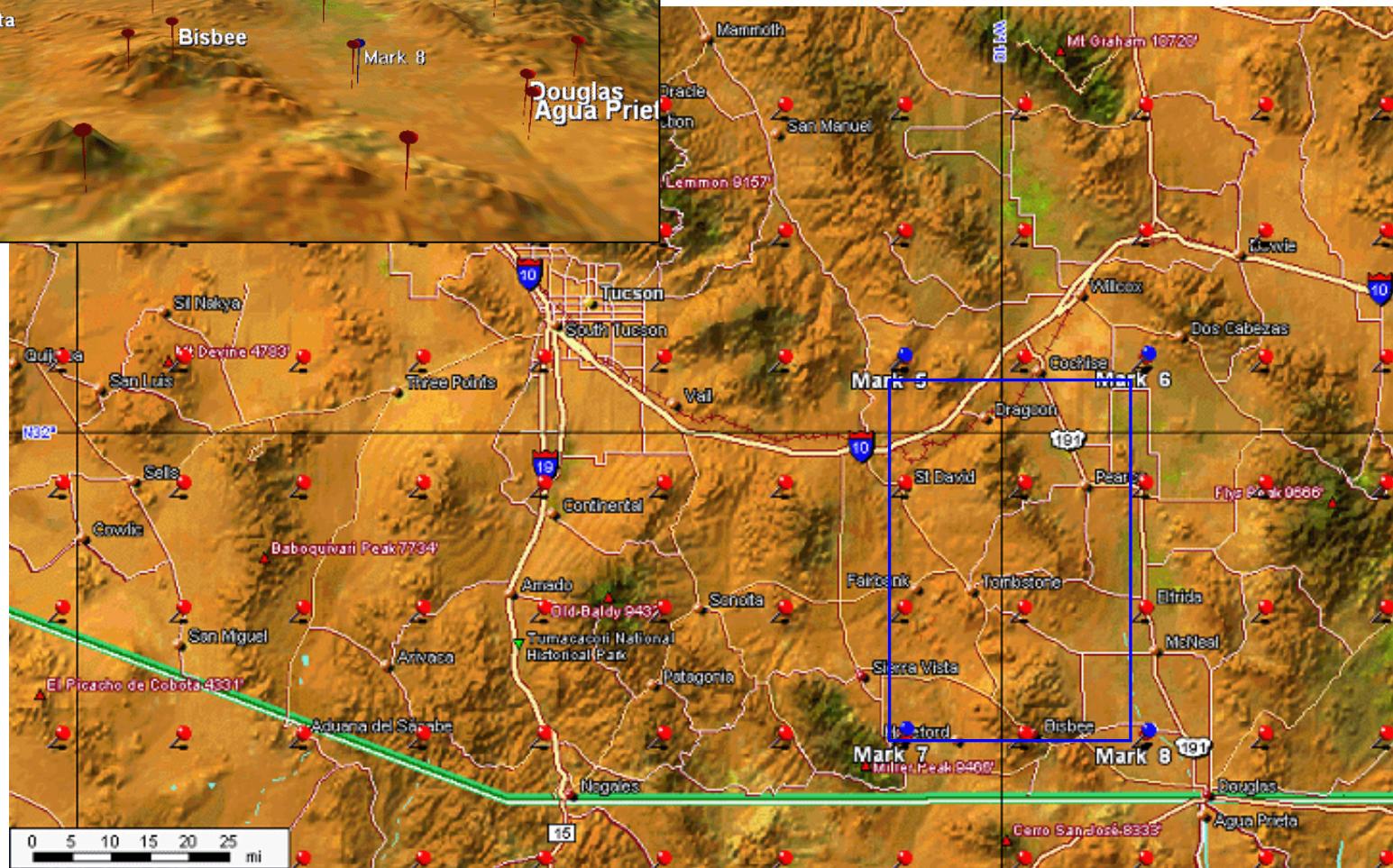
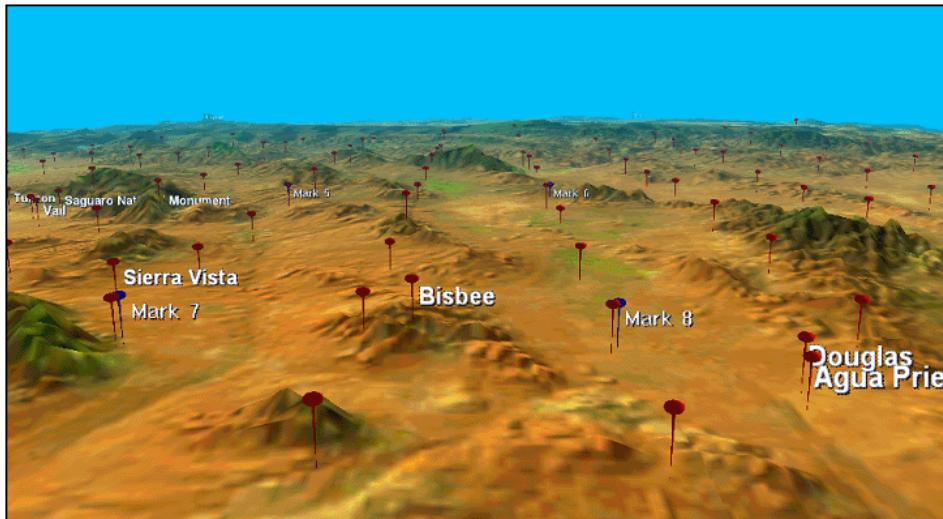
As part of NAME there will be an intensive observing period in the summer of 2004 over the Tier I domain. The intention of SMEX04-NAME is to enhance the terrestrial hydrology component of NAME by facilitating development of soil moisture. Specific activities include the provision of soil moisture products from the existing insitu network in Arizona and the development of an equivalent network within a study region in Mexico, and soil moisture products derived from existing satellite sensors on Aqua and TRMM. An intensive ground and aircraft field campaign will take place between mid July and mid August 2004 that will provide validation of the insitu and satellite products. SMEX04-NAME will also address important algorithm and validation issues for existing satellite based soil moisture products from the Advanced Microwave Scanning Radiometer and



# NASA AMSR and Terrestrial Hydrology Program Soil Moisture Priorities

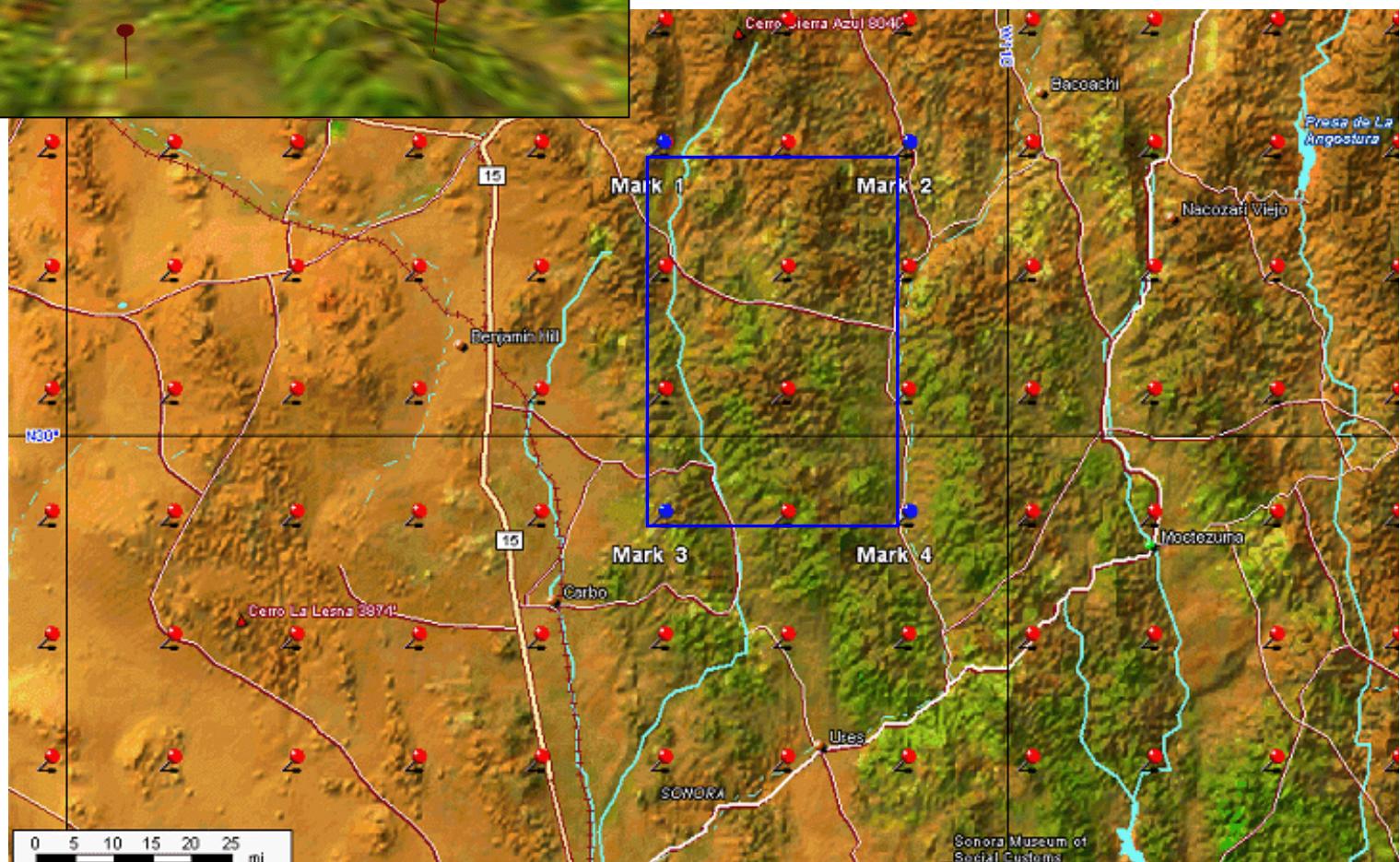
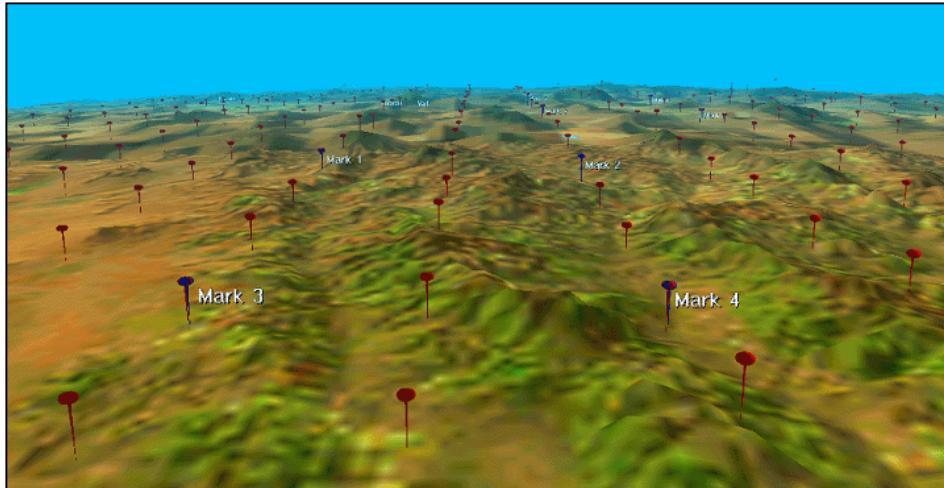
1. Development and validation of retrieval algorithms in regions with **moderate to significant topographic variation**;
2. Validation of soil moisture products from the Aqua and ADEOS-II AMSR instruments;
3. Establishing long-term in-situ soil moisture validation sites for satellite based retrievals;
4. Evaluation of new sensor technologies and algorithms for soil moisture;
5. Understanding the feedback mechanisms of surface soil moisture on weather and climate;
6. Development of methods to assimilate surface soil moisture observations in models.

# Walnut Gulch Regional Study Area (WG)



Red markers are the corners of the 25 km Ease Grid cells

# Mexico Regional Study Area (MX)



Red markers are the corners of the 25 km Ease Grid cells

# **SMEX04 Elements**

- In-situ soil moisture networks
- Aircraft mapping
- Intensive sampling concurrent with aircraft mission
- Satellite products

# **SMEX04 Elements: In-situ soil moisture networks**

- Modeled after current AMSR Cal/Val project 12 or more long term in-situ sites
- All sites have 5 cm soil moisture and temperature (Vitel Hydraprobe) and precipitation
- Walnut Gulch is already instrumented
- A region in Mexico is being instrumented

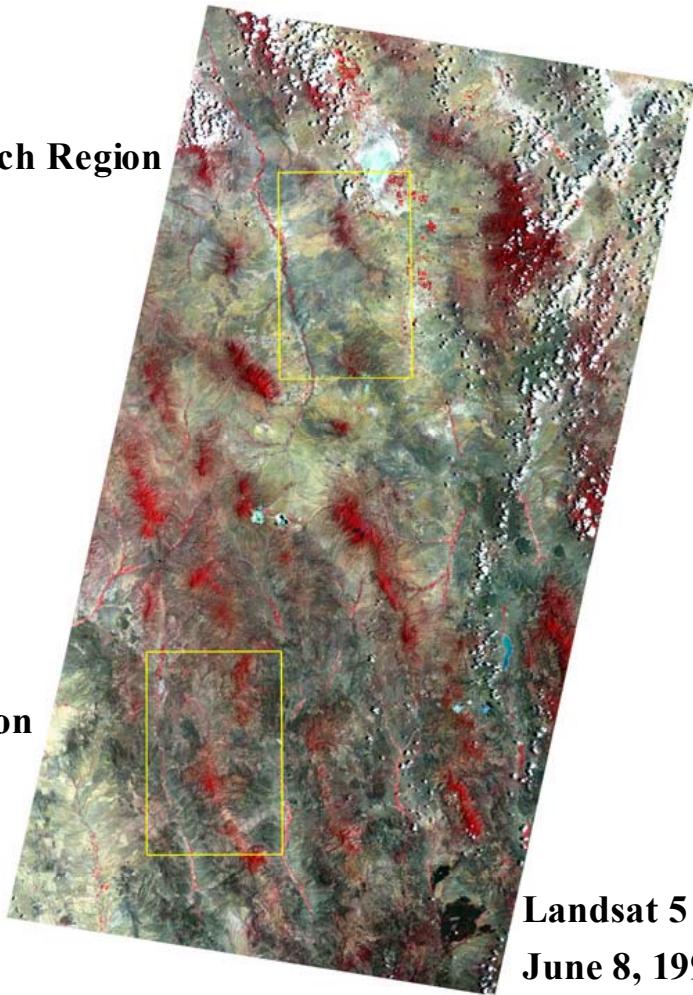


**Arizona**

**Walnut Gulch Region**

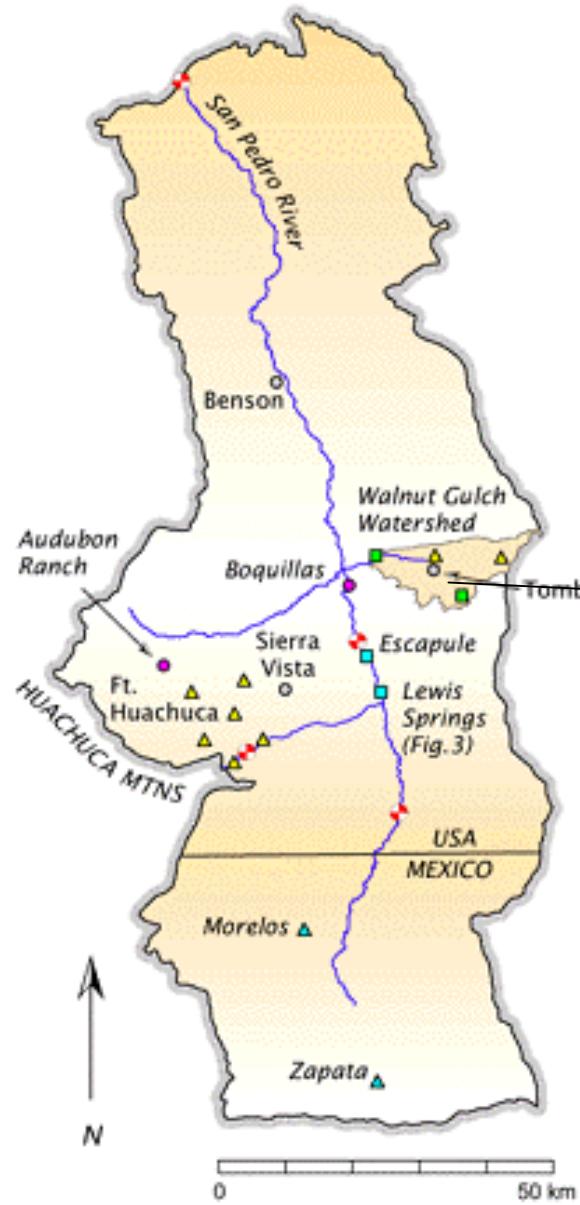
**Mexico**

**Sonora Region**



Regional study areas  
50 by 75 km linked to  
Ease-grid 25 km cells

**Landsat 5**  
**June 8, 1997**



## Walnut Gulch Soil Moisture Sites

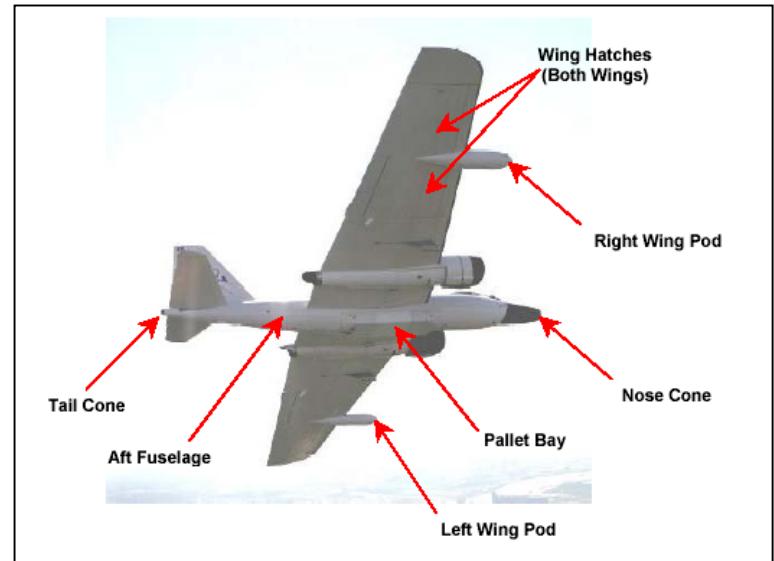
| RG#                 | Easting (m) | Northing (m) | Elev. (m) |
|---------------------|-------------|--------------|-----------|
| 3                   | 581265      | 3509566      | 1253      |
| 13                  | 586181      | 3509986      | 1327      |
| 14                  | 585495      | 3506970      | 1373      |
| 18                  | 586778      | 3507884      | 1358      |
| 20                  | 587543      | 3504739      | 1519      |
| 28                  | 590669      | 3509803      | 1369      |
| 34                  | 591018      | 3507252      | 1420      |
| 37                  | 593354      | 3505864      | 1407      |
| 40                  | 593449      | 3510092      | 1392      |
| 57                  | 596162      | 3512115      | 1462      |
| 69                  | 603982      | 3515260      | 1640      |
| 70                  | 604327      | 3514015      | 1632      |
| 76                  | 582707      | 3509391      | 1312      |
| 89                  | 596373      | 3513731      | 1483      |
| 92                  | 581955      | 3511576      | 1251      |
| 100                 | 593548      | 3504309      | 1436      |
| Profile Sites       |             |              |           |
| 46                  | 595346      | 3508470      | 1440      |
| 82                  | 600225      | 3511469      | 1521      |
| 83                  | 589765      | 3512232      | 1367      |
| Off Watershed Sites |             |              |           |
| 400                 | 582120      | 3518828      | 1266      |
| SP                  | 577947      | 3503457      | 1215      |

# **SMEX04 Elements:**

## **Aircraft Overview**

- NASA JSC WB-57
- July 15 – August 15, 2004
- Aircraft sensors
  - PSR and an L band
- Mission
  - 15 flight dates, 5 hours per day
  - Walnut Gulch and Mexico sites (50 by 75 km)
  - 4 flightlines per site

# NASA JSC WB57 Aircraft



# **SMEX04 Elements: Intensive Sampling Concurrent with Aircraft Mission**

- Calibration of network
- Fills in the spatial domain
- Two teams (Walnut Gulch and Mexico)
- Mexico partnership with local institutions
- Model will be that developed for SMEX02 and SMEX03



# Status

- Core team formed: HRSL, JPL, ARS Tucson, IMADES (Mexico), Univ. Arizona
- Aircraft identified: WB57
- PSR being adapted
- L band TBD
- Team Workshop (onsite and telecon)
- [hydrolab.arsusda.gov/smex04/](http://hydrolab.arsusda.gov/smex04/)

# **STATUS/PLANS**

- **SMEX02**
  - DAAC Wrap up
  - EOS Article
  - RSE Special Issue
- **SMEX03**
  - Data Processing
  - DAAC Initiation
  - AGU Fall/IGARSS
- **SMEX04**
  - Insitu Network
  - Telecons in November
  - Planning Workshop February
- **SMEX??**
  - Europe, Canada, .....

# SMEX

## Data Set

### Status

#### Oct. 14, 2003

| Group          | Data Set          | SMEX02 | SMEX03 |    |       |    | SMEX04 |
|----------------|-------------------|--------|--------|----|-------|----|--------|
|                |                   |        | GA     | AL | OS/ON | BZ |        |
| Aircraft       | PSR               | ●      | ○      | ○  | ○     | ○  |        |
|                | 2DSTAR            | ○      | ○      | ○  | ○     | ○  |        |
|                | GPS               | ●      | ○      | ○  | ○     | ○  |        |
|                | AIRSAR            | ●      | -      | -  | ○     | -  |        |
| Ancillary      | Land Cover        | ●      | ○      | ○  | ○     | ○  |        |
|                | Geolocation       | ●      | ○      | ○  | ●     | ○  |        |
|                | Soils             | ●      | ○      | ○  | ●     | ○  |        |
|                | Surface Roughness | ●      | ○      | ○  | ●     | ○  |        |
| Soil Moisture  | Regional          | ●      | ○      | ○  | ●     | ○  |        |
|                | Watershed         | ●      | -      | -  | ●     | -  |        |
|                | Vitel Network     | ●      | ○      | -  | ●     | ○  |        |
|                | SCAN              | ●      | ●      | ●  | ●     | -  |        |
| Meteorological | Flux Towers       | ○      | ○      | -  | -     | -  |        |
|                | Precipitation     | ●      | ○      | ○  | ●     | ○  |        |
|                | Apogee Network    | ●      | -      | -  | ●     | -  |        |
|                | Mesonet           | -      | -      | -  | ○     | -  |        |
|                | ARM               | -      | -      | -  | ○     | -  |        |
|                | SCAN              | ●      | ●      | ●  | ●     | ○  |        |
| Satellite      | AMSR              | ○      | ○      | ○  | ○     | ○  |        |
|                | ASAR Imagery      | -      | ○      | ○  | ●     | ○  |        |
|                | ASTER             | ●      | -      | -  | ●     | ○  |        |
|                | AVHRR             | ○      | ○      | ○  | ○     | ○  |        |
|                | GOES              | ○      | ○      | ○  | ○     | ○  |        |
|                | NDVI/NDWI         | ●      | ○      | ○  | ○     | ○  |        |
|                | Quikscat          | ○      | ○      | ○  | ○     | ○  |        |
|                | SSM/I             | ●      | ○      | ○  | ○     | ○  |        |
|                | TERRA-MODIS       | ●      | ○      | ○  | ○     | ○  |        |
|                | TM Imagery        | ●      | ●      | ●  | ●     | ●  |        |
|                | TMI               | -      | ●      | ●  | ●     | ●  |        |
|                | Regional          | ●      | ○      | ○  | ●     | ○  |        |
| Vegetation     | Watershed         | ●      | -      | -  | ●     | -  |        |

- Completed/  
Submitted to DAAC
- Currently in  
Quality Control
- Early Stages of  
Quality Control
- Not Part of Data  
Set

# **STATUS/PLANS**

- **SMEX02**
  - DAAC Wrap up
  - EOS Article
  - RSE Special Issue
- **SMEX03**
  - Data Processing
  - DAAC Initiation
  - AGU Fall/IGARSS
- **SMEX04**
  - Insitu Network
  - Telecons in November
  - Planning Workshop February
- **SMEX??**
  - Europe, Canada, .....